EXHIBIT 24

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

TQ DELTA, LLC, *Plaintiff,* v. **COMMSCOPE HOLDING COMPANY, INC., COMMSCOPE INC., ARRIS INTERNATIONAL LIMITED, ARRIS GLOBAL LTD., ARRIS US HOLDINGS, INC., ARRIS SOLUTIONS, INC., ARRIS TECHNOLOGY, INC., and ARRIS ENTERPRISES, LLC,** *Defendants.*	CIV. A. NO. 2:21-CV-310-JRG (Lead Case)
TQ DELTA, LLC, *Plaintiff,* v. **NOKIA CORP., NOKIA SOLUTIONS AND NETWORKS OY, and NOKIA OF AMERICA CORP.,** *Defendants.*	CIV. A. NO. 2:21-CV-309-JRG (Member Case)
NOKIA OF AMERICA CORP., *Third-Party Plaintiff,* v. **BROADCOM CORP., BROADCOM INC., and AVAGO TECHNOLOGIES INTERNATIONAL SALES PTE. LTD.,** *Third-Party Defendants.*	

DECLARATION OF GEORGE A. ZIMMERMAN, PH.D.
REGARDING CLAIM CONSTRUCTION

TABLE OF CONTENTS

I. INTRODUCTION

1. My name is George A. Zimmerman, Ph.D., and I have been retained as a technical expert by counsel for Defendants Nokia of America Corporation, Nokia Corporation, Nokia Solutions and Networks Oy (collectively, "Nokia") and CommScope Holding Company, Inc., CommScope Inc., ARRIS US Holdings, Inc., ARRIS Solutions, Inc., ARRIS Technology, Inc., and ARRIS Enterprises, LLC (collectively, "CommScope") (together, "Defendants") to address certain issues concerning U.S. Patent No. 7,453,881 (the "'881 Patent"), U.S. Patent No. 9,014,193 (the "'193 Patent"), U.S. Patent No. 9,300,601 (the "'601 Patent") (collectively, "Certain Family 2 Patents"), U.S. Patent No. 8,090,008 (the "Family 4 Patent," or the "'008 Patent"), U.S. Patent No. 9,154,354 (the "'354 Patent" or the "Family 10 Patent"), which have been asserted by TQ Delta, LLC ("Plaintiff" or "TQ Delta"). Unless otherwise stated, the matters contained in this declaration are of my own personal knowledge and, if called as a witness, I could and would testify competently and truthfully regarding the matters set forth herein.

2. My opinions are based on my years of education, research and experience, as well as my investigation and study of relevant materials. In forming the opinions set forth in this declaration, I have reviewed the Certain Family 2 Patents, Family 4 Patent, Family 10 Patent, and their file histories, as well as the provisional application to which the Family 4 Patent claims priority, Provisional Application No. 60/164,134 (the "'134 Provisional"), and the provisional application to which the Family 10 Patent claims priority, Provisional Application No. 60/197,727 ("the '727 Provisional"). A list of materials considered is included in **Exhibit A** to my declaration.

3. I may rely upon these materials, my knowledge and experience, and/or additional materials, documents, and information in forming any opinions in this Action, including but not

limited to opinions to rebut arguments raised by Plaintiff. I reserve all rights that I may have to supplement this declaration if further information becomes available or if I am asked to consider additional information. Furthermore, I reserve all rights that I may have to consider and comment on any additional expert statements or testimony of Plaintiff's experts in this matter.

4. My analysis of materials relevant to this Action is ongoing, and I may continue to review new material as it is becomes available. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided. I also reserve the right to create exhibits to use in Court if called upon to testify.

5. I am being compensated at my usual consulting rate of $300 per hour for my time spent working on issues in this case. My compensation does not depend upon the outcome of this matter or the opinions I express.

II. QUALIFICATIONS

6. I have summarized in this section my educational background, work experience, and other relevant qualifications. A true and accurate copy of my curriculum vitae is attached as **Exhibit B** to this declaration.

7. In 1985, I received a Bachelor of Science degree in Electrical Engineering from Stanford University. In 1988, I received a Master of Science degree in Electrical Engineering from the California Institute of Technology. In 1990, I completed my doctoral thesis on interference cancellation for multi-access communications and received a Ph.D. in Electrical Engineering from the California Institute of Technology.

8. From 1985 to 1995, I held system engineering, digital design, and engineering management positions as a Member of Technical Staff at Jet Propulsion Laboratory in Pasadena,

California. At JPL, I was a leader on the SETI project. I also helped design the ground data processors that made radar images of the surface of Venus (the Magellan spacecraft). I also worked on other projects related to national security.

9. From 1989 to 1995, I was an independent consultant in the areas of communications and signal-processing analysis, including design and architecture of data transmission and storage equipment for various commercial vendors. Between 1992 and 1994, I was a lecturer at the California Institute of Technology on communications systems and related topics.

10. From 1995 through June 2000, I was the Chief Scientist at PairGain Technologies. PairGain was a pioneering firm in the DSL and broadband-networking space who made a full line of DSL-based broadband-access products including DSL line cards, DSLAMs, DSL access switches, DSL CPE, and chipsets for HDSL, ADSL, and HDSL2. At PairGain, I personally performed research, worked on standards development, developed strategy, and interfaced extensively with customers on their plans for deploying DSL.

11. In my capacity as Chief Scientist at PairGain, I participated in the formulation of standards for DSL transmission and systems, including the ADSL Forum, Committee T1E1.4, and the ITU-T G.992 series of DSL standards. I was a member and regular participant in ANSI T1E1.4 and ITU-T standards meetings on digital subscriber line technology from 1995 through 1999, including authoring contributions and voting regularly.

12. In my duties at PairGain, I was involved in concept, design, and helping customers deploy HDSL, DMT ADSL, CAP ADSL, and SDSL solutions, for central office, subscriber premises, and outside plant operations, including the first tariffed DSL internet access services in the United States.

13. From January 2001 through May 2011, I was the founder and Chief Technical Officer of Solarflare Communications, a leading provider of 10 Gigabit Ethernet server adapters and silicon. Solarflare developed chipsets and drove an IEEE standard for 10Gps Ethernet technology over twisted pair wiring known as 10GBASE-T, or IEEE Std. 802.3an-2006. The company sold 10GBASE-T chipsets to various OEMs, including Dell, for use in Ethernet switches and server adapters. The Solarflare 10GBASE-T business was sold to Marvell Semiconductor in May 2011, at which time I departed the company.

14. From May 2003 through May 2009, I was involved with Aktino Corporation, a designer and manufacturer of multi-pair bonded DSL transmission equipment for service providers. From 2003 through 2005, I served on the Board of Directors. And from 2005 through 2009, I served as a technology advisor to the company.

15. From May 2011 to date, I have been the principal consultant at CME Consulting, specializing in wireline communications, including Ethernet and proprietary systems over twisted-pair wiring, similar to DSL. As part of my work at CME Consulting, I have been actively continuing my work on physical-layer specifications for data transmission over twisted-pair copper lines. I am a member of the IEEE 802.3 Ethernet Working Group, and was Chief Editor for two standards, IEEE Std 802.3bq-2016 25GBASE-T and 40GBASE-T and IEEE Std 802.3bz-2016 2.5GBASE-T and 5GBASE-T. These specify physical-layer interfaces for Ethernet on twisted-pair copper lines. I am currently Chair of the IEEE P802.3cg 10 Mb/s Single Twisted Pair Ethernet Task Force, which is working on developing a specification for 10 Mb/s transmission on a single, twisted-pair copper line at distances up to 1 km.

16. I am also the technical committee chair of the Ethernet alliance, and on the board of the NBASE-T alliance, which is an industry body that works exclusively on twisted-pair

copper data transmission. "The NBASE-T Alliance focuses on building the ecosystem and consensus required to enable a new 2.5GBASE-T/5GBASE-T Ethernet standard. Working with key stakeholders, the consortium releases specifications that define 2.5 and 5 Gigabit per second (Gbps) speeds at up to 100 meters using the large, installed base of copper cabling in enterprise networks." (www.nbaset.org/alliance/.) I therefore have experience beyond DSL in other data communications over twisted-wire pairs.

17. I have written and/or edited numerous technical publications, many of which focus on networking and communications technology. Several of them focus specifically on wireline networking technology, DSL, and aspects of data transmission in the telephone company local loop and similar environments. Exemplary publications include:

- Gergely Huszak, Hiroyoshi Morita, George Zimmerman, "Backward-Compatible Forward Error Correction of Burst Errors and Erasures for 10BASE-T1S", IEICE Transactions on Communications, Vol. E104-B, No. 12, December 1, 2021, pp. 1524-1538 DOI: 10.1587/transcom.2021EBP3016.
- G. Zimmerman, "Power Backoff," IEEE P802.3an Task Force Contributions: Zimmerman_1_0205.pdf, Zimmerman_1_0305.pdf, Zimmerman_2_0305.pdf, February & March 2005.
- G.A. Zimmerman, "Approaches to CSA-Reach Single-Pair HDSL," PairGain contribution, T1E1.4/96-160, March 1995.
- G.A. Zimmerman, "Normative Text for Spectral Compatibility Evaluations," PairGain contribution, T1E1.4/97-180R1, June 30, 1997.
- G.A. Zimmerman, "Achievable rates vs. operating characteristics of local loop transmission: HDSL, HDSL2, ADSL and VDSL," Signals, Systems & Computers, 1997.

Conference Record of the Thirty-First Asilomar Conference on Signals, Systems and Computers, Volume 1, 2-5 Nov. 1997 Pages: 573-577 vol. 1.

18. I am also the named inventor on numerous patents and patent applications in networking and communications technology, including high-speed networking devices. Exemplary patents include:

- U.S. Patent 10,754,409, ENERGY EFFICIENT ETHERNET WITH MULTIPLE LOW-POWER MODES, S. Benyamin, P. Langer, G. Zimmerman, August 25, 2020.
- U.S. Patent No. 10,790,997, TRANSMISSION OF PULSE POWER AND DATA IN A COMMUNICATIONS NETWORK, C. Jones, J. Goergen, G. Zimmerman, R. O'Brien, D. Arduini, J. Potterf, S. Baek, September 29, 2020.
- U.S. Patent No. 10,291,285, METHODS FOR PERFORMING MULTI-DISTURBER ALIEN CROSSTALK LIMITED SIGNAL-TO-NOISE RATIO TESTS, B. Boban and G. Zimmerman, November 4, 2016.
- U.S. Patent No. 6,912,208: METHOD AND APPARATUS FOR JOINT EQUALIZATION AND CROSSTALK MITIGATION, G. Zimmerman and W. Jones, June 28, 2005.
- U.S. Patent No. 7,002,897: MULTIPLE CHANNEL INTERFERENCE CANCELLATION, W. Jones and G. Zimmerman, February 21, 2006.
- U.S. Patent No. 7,352,687: MIXED DOMAIN CANCELLATION, W. Jones, G. Zimmerman and C. Pagnanelli, April 1, 2008.
- U.S. Patent No. 7,164,764: METHOD AND APPARATUS FOR PRECODE CROSSTALK MITIGATION, G. Zimmerman and W. Jones, January 16, 2007.

- U.S. Patent No. 7,808,407: SUB-CHANNEL DISTORTION MITIGATION IN PARALLEL DIGITAL SYSTEMS, G. Zimmerman and W. Jones, October 5, 2010.
- US. Patent No. 8,984,304: ACTIVE IDLE COMMUNICATION SYSTEM, G. Zimmerman, November 12, 2007.
- U.S. Patent No. 9,883,457, METHOD AND APPARATUS FOR REDUCING POWER CONSUMPTION OF A COMMUNICATIONS DEVICE DURING PERIODS IN WHICH THE COMMUNICATIONS DEVICE RECEIVES IDLE FRAMES FROM ANOTHER COMMUNICATIONS DEVICE, G. Zimmerman, March 16, 2015.
- U.S. Patent No. 5,459,680: METHOD AND APPARATUS FOR SPUR-REDUCED DIGITAL SINUSOID SYNTHESIS, G. Zimmerman and M. Flanagan, October 17, 1995.
- U.S. Patent No. 5,068,859: LARGE CONSTRAINT LENGTH HIGH SPEED VITERBI DECODER BASED ON A MODULAR HIERARCHICAL DECOMPOSITION OF THE DeBRUIJN GRAPH, by O. Collins, et al., November 26, 1991

19. A complete list of cases in which I have testified at trial, hearing, or by deposition within the preceding five years is provided in my curriculum vitae, which is attached as **Exhibit B** to my declaration.

20. Based on my education and experience, I believe I am qualified to render the opinions set forth here.

III. SCOPE OF OPINIONS

21. I have been asked to provide opinions regarding the meaning of certain disputed claim terms as understood by one of ordinary skill at the time of the claimed alleged inventions. My opinions are based on my understanding of the disputed claim terms and proposed constructions and the evidence relied on by the parties.

IV. LEGAL STANDARDS

22. Certain legal principles that relate to my opinions have been explained to me by counsel.

23. I understand that ultimately the Court will determine how specific terms shall be construed. The intent of this declaration is to help inform the Court how a person of ordinary skill in the art would have understood the meaning of certain disputed claim terms at the time of the claimed alleged inventions in the context of the Asserted Patents' claims, specifications, and prosecution histories in a manner that will assist the Court in the process of construing the claims. I understand that patent claims are generally given the meaning that the terms would have to a person of ordinary skill in the art in question as of the earliest claimed priority date. It is my understanding that a patentee can act as its own lexicographer by defining a term, in the patent specification, to have specific meaning. It is my understanding that statements made to the patent office by the patentee or its legal representative during prosecution can serve to illuminate, or possibly narrow the proper scope of claim terms, and that such statements must be considered when construing the claim terms. This is sometimes referred to as disclaimer. I have taken into account these principles in my analysis.

24. I understand that a claim is indefinite if, when read in light of the specification and its prosecution history, the claim fails to inform, with reasonable certainty, those skilled in the art about the scope of the claimed invention.

25. I understand that a patent may include both independent and dependent claims. I understand that a claim in dependent form must contain reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form must be construed to incorporate by reference all the limitations of the claim on which it depends.

V. BACKGROUND

A. Certain Family 2 Patents

26. I have been asked to provide opinions regarding the meaning of certain claim terms in the ’881 Patent, the ’193 Patent, and the ’601 Patent.

27. The ’881 patent is titled “SYSTEMS AND METHODS FOR MULTI-PAIR ATM OVER DSL.” The ’193 and ’601 patents are titled “BONDING DEVICE AND METHOD.”

28. I understand that TQ Delta has asserted the following claims and priority dates:

Patent	Asserted Claims[1]	Asserted Priority Date
’881 Patent	17, 18, 21, 23, 25, 26, 29, 31, 33, 34, 37, 38	October 5, 2001
’193 Patent	1, 9, 10, 12, 13	October 5, 2001
’601 Patent	8, 9, 13, 14, 15, 16, 17, 18, 21	October 5, 2001

29. I have been asked to assume the applicability of the priority dates for these patents as detailed above and have therefore analyzed the claim constructions and knowledge of one of ordinary skill for the patents as of those dates.

30. The ’881, ’193, and ’601 patents all share a common specification except that the ’193 and ’601 patents include a Figure 16 and description thereof, which are not present in the ’881 patent. Below I describe the ’881 patent, but the description is equally applicable to the ’193 and ’601 patents.

31. The ’881 patent discusses systems and methods to “combine multiple DSL PHY’s, i.e., multiple twisted wire pairs, to, for example, generate a high data rate connection for the transport of an ATM cell stream between the service provider and, for example, a DSL subscriber.” ’881 patent at col. 1:60-64. A transmitter transmits cells from a single ATM cell stream over multiple twisted pairs, and the receiver recombines the cells from each twisted pair

[1] I understand the ’881 patent is asserted only against CommScope and the ’193 and ’601 patents are asserted only against Nokia.

in the appropriate order to recreate the original cell stream. *Id.* at col. 1:67-2:5. FIG. 2 of the patent, copied below, illustrates the disclosed multi-pair ATM over DSL system. *Id.* at col. 3:58-59.

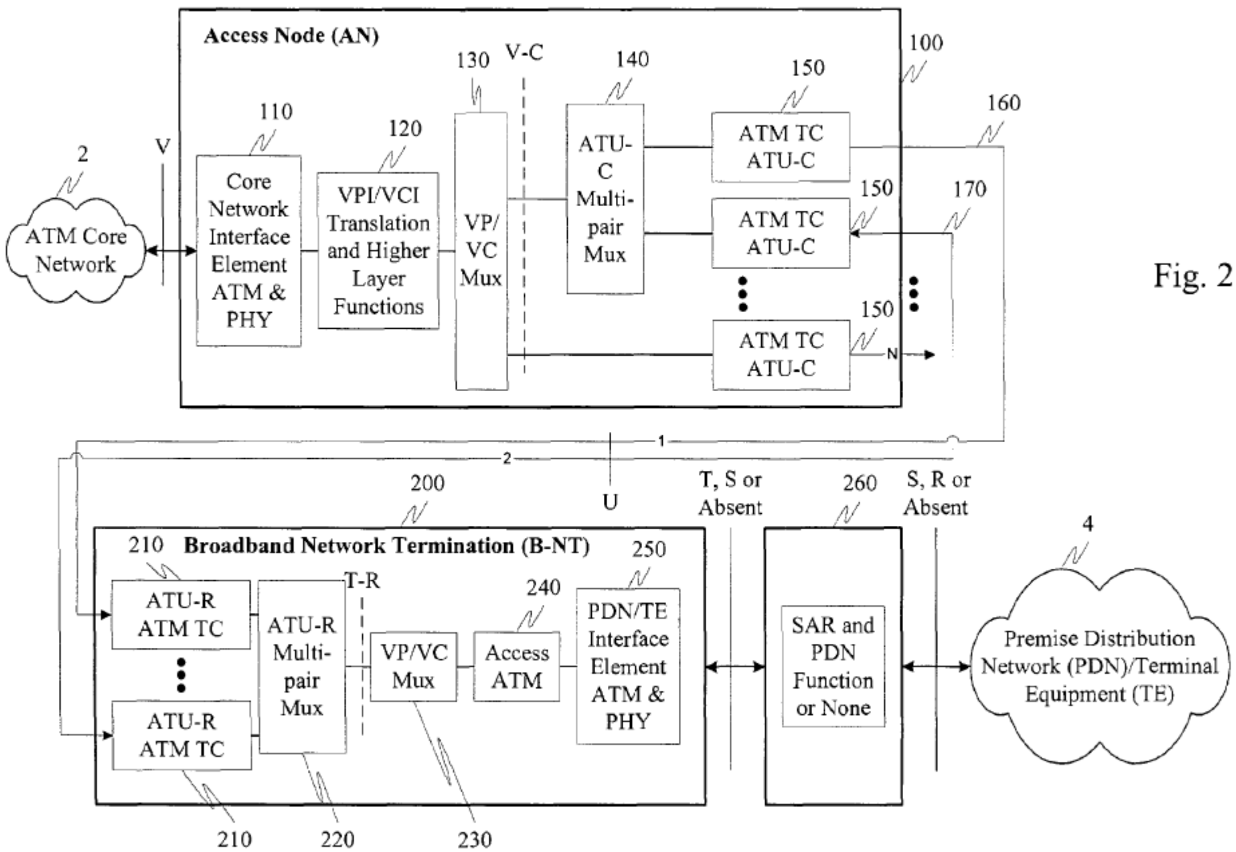

Fig. 2

32. On the service provider's side, at the access node, an ATU-C multi-pair multiplexer 140 sits between the virtual path/virtual circuit (VP/VC) multiplexer 130 and the ATU-Cs 150. *Id.* at col. 4:15-18. On the subscriber's side, at the broadband network termination, an ATU-R multi-pair multiplexer 220 sits between the ATU-Rs 210 and a VP/VC multiplexer 230. *Id.* at col. 4:18-20.

33. Both the ATU-C multi-pair multiplexer 130 and the ATU-R multi-pair multiplexer 220 "have transmitter and receiver sections (not shown) whose operations are comparable." *Id.* at col. 4:20-22. The transmitter of each multi-pair multiplexer creates the ATM

cell substreams, each of which is forwarded to a different ATU for transmission. *Id.* at col. 4:22-26. When the DSL PHYs provide different data rates, the multi-pair multiplexers are able to forward ATM cells "at, for example a ratio that matches the ratios of the available PHY data rates." *Id.* at col. 5:22-27.

34. The ATM cells transported over different physical links can have different end-to-end delays, or latencies. *Id.* at col. 6:2-4. As a result of the different physical links having different latencies, "it is possible that an ATM cell that was sent over a DSL PHY may be received at the multi-pair multiplexing receiver after an ATM cell that was sent out later on a different DSL PHY." *Id.* at col. 6:32-35. This complicates the reassembly process at the multi-pair multiplexer, because the multiplexer "must be able to reconstruct the ATM stream even if the ATM cells are not being received in the same order as they where [sic] transmitted." *Id.* at col. 6:6-9.

35. The specification describes four sources of latency that can cause a difference in latency from one twisted pair to another. *Id.* at col. 6:10-31. The first source of latency is configuration latency, which "is based on the configuration of the DSL transmission parameters," including "the data rate, coding parameters, such as coding method, codeword size, interleaving parameters, framing parameters, or the like." *Id.* at 6:12-16. The second source of latency is Asynchronous Transfer Mode Transmission Convergence (ATM-TC) latency, which is "based on cell rate decoupling in the ATM-TC" when the "ATM-TC block in ADSL transceivers performs cell rate decoupling by inserting idle cells according to the ITU Standard I.432 . . ." *Id.* at col. 6:17-21. ATM-TC latency is dictated by and dependent on standard-based parameters and the timing of a transceiver and the state of its buffers. *Id.* at col. 6:20-24. The third source of latency is "wire latency," which results from DSL electrical signals "experienc[ing] different

delays based on the difference in the length of the wire, the gauge of the wire, the number [of] bridged taps, or the like." *Id.* at col. 6:25-28. The fourth source of latency is "design latency," which is "based on differences in the DSL PHY design," and "can also depend on the design chosen by the manufacturer." *Id.* at col. 6:29-31. The differential latency is the difference in latency from one line to another as a result of different contributions from the four sources of latency. *Id.* at col. 6:2-5; *see also id.* at col. 6:10-31.

36. The '881 patent describes reducing differential latency by "mandat[ing] that all DSL PHYs are configured with transmission parameters in order to provide the same configuration latency." *Id.* at col. 6:56-59. One way to provide the same configuration latency on each DSL PHY is "by configuring the exact same data rate, coding parameters, interleaving parameters, etc. on all DSL PHYs." *Id.* at col. 6:60-62. If different twisted pairs support different data rates, the specification describes "us[ing] the appropriate coding or interleaving parameters to have the same latency on all the bonded PHYs." *Id.* at col. 6:62-65.

37. As an example of using the appropriate coding or interleaving parameters to have the same latency on all bonded PHYs when the data rates differ, the '881 patent identifies the "Reed Solomon coding and interleaving functions as defined in ADSL standards G.992.1 and G.992.3" and notes that the latency is N*D/R, "where N is the number of bits in a codeword, D is the interleaver depth in codewords and R is the data [rate] in bits per second." *Id.* at col. 6:66-7:6. The specification teaches that if two DSL PHYs have different data rates, then "in order to bond these PHYs together and have the same configuration latency set:

N1*D1/R1=N2*D2/R2,

where N1 and N2 are the bits in a codeword for each PHY and D1 and D2 are the interleaver depths for each PHY." *Id.* at col. 7:11-17. To set the configuration latencies equal to one another,

the specification teaches that "the N1, N1 [sic, D1], N2 and D2 parameters must be chosen to satisfy the above equations." *Id.* at col. 7:22-23 (emphasis added).

38. The specification provides a specific example: "if the configuration latency is specified as 0.016 seconds, and R1=6400000 bps and R2=1600000 then, as described in the example above, N1 anss [sic] D1 can be configured as N1=1600 and D1=64. Therefore:

N2*D2=(R2/R1)*D1*N1=(1600000/6400000)*1600*64=1600*64/4.

Therefore, for example, N2 and D2 can be configured as (N2=1600, D2=16) or (N2=400, D2=64) or (N2=800, D2=32), etc." *Id.* at col. 7:25-34.

39. The '881 patent purports to incorporate by reference DSL Forum Recommendation TR-042 ("TR-042"), entitled "ATM Transport over ADSL Recommendation" and dated August 2001. *Id.* at col. 1:21-25. TR-042 "addresses implementation aspects specific to the transport of Asynchronous Transfer Mode (ATM) traffic over Access Networks based on Asymmetric Digital Subscriber Line (ADSL) technology." TR-042 at § 1. Its objective is to specify the transport of ATM over ADSL in a manner that is consistent with the then-existing ADSL Recommendations, namely ANSI T1.413, ITU-T G.992.1, and ITU-T G.992.2. *Id.*

40. TR-042 notes that the interleaver used in ADSL is configurable, that its use causes additional latency, and that network operators can use the configurability of the interleaver to adjust the effectiveness of the forward error correction. TR-042 at § 4.3 ("The ADSL PHY Recommendations specify a configurable interleaver for protection against impulse noise. The interleaver configuration allows the Network Operator to deliver different service qualities by adjusting the effectiveness of the Forward Error Correction mechanism over the ADSL Access Network. This interleaver mechanism introduces additional latency as a side-effect.").

B. Family 4 Patent

41. I have been asked to provide opinions regarding the meaning of certain claim terms in the ’008 Patent.

42. The ’008 Patent is titled “System and method for scrambling the phase of the carriers in a multicarrier communications system.”

43. I understand that TQ Delta has asserted the following claims and priority dates:

Patent	Asserted Claims	Asserted Priority Date
’008 Patent	14	November 9, 1999 or, in the alternative, November 9, 2000, or, in the alternative, August 26, 2005, or, in the alternative, September 7, 2007, or in the alternative, October 22, 2008

44. I have been asked to assume the applicability of priority dates for this patent as detailed above and have therefore analyzed the claim constructions and knowledge of one of ordinary skill for the patents as of those dates.

45. In forming the opinions set forth in this declaration, I have reviewed the asserted Family 4 Patent and its file history, as well as the ’134 Provisional, the provisional application to which the Family 4 Patent claims priority.

46. The ’008 Patent generally describes transmission and reception using multicarrier modulation or Discrete Multitone Modulation (DMT). ’008 Patent at 1:33-36. In a DMT transmitter, “[c]arrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system.” ’008 Patent at 1:36-39. “The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the

input signal." '008 Patent at 1: 40-45. The alleged invention of the '008 Patent is directed to "a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal." '008 Patent at 2:34-36.

47. With respect to the background of the invention, I reserve the right to respond to TQ Delta's expert's description should a more detailed description of DMT transmission and reception become necessary.

C. Certain Family 10 Patent

48. I have been asked to provide opinions regarding the meaning of certain claim terms in the '354 Patent.

49. The Family 10 Patent is titled "Systems And Methods For A Multicarrier Modulation System With A Variable Margin."

50. I understand that TQ Delta has asserted the following claims and priority dates:

Patent	Asserted Claims	Asserted Priority Date[2]
'354 Patent	10–12	April 18, 2000

51. I have been asked to assume the applicability of priority dates for this patent as detailed above and have therefore analyzed the claim constructions and knowledge of one of ordinary skill for the patents as of this date.

52. The '354 Patent discusses a system and method to "allow the margin in a discrete multitone modulation system to vary depending on a type of impairment . . . [which] can be changing over some duration or from one installation to another." '354 Patent at 3:27–31. "In an

[2] I understand that TQ Delta offered many alternative priority dates in its Preliminary Infringement Contentions, dated November 4, 2021. I have included the earliest asserted priority date for each asserted patent in this chart, which does not constitute an admission that these patents are entitled to claim priority to that date.

exemplary embodiment of the invention, the margin is set to be different on at least two subchannels in a discrete multitone modulation system. . . [where] subchannels which are expected to incur greater variations in impairment levels are set to have a higher margin, whereas subchannels which are expected to incur lower variations in impairment levels are set to have lower margins." '354 Patent at 4:14–20.

53. The system can be implemented by a ADSL modem or similar system. *See* '354 Patent at 9:11–21. "FIG. 2 illustrates an exemplary method of assigning margins to carriers according to an exemplary embodiment of this invention." '354 Patent at 8:7–9.

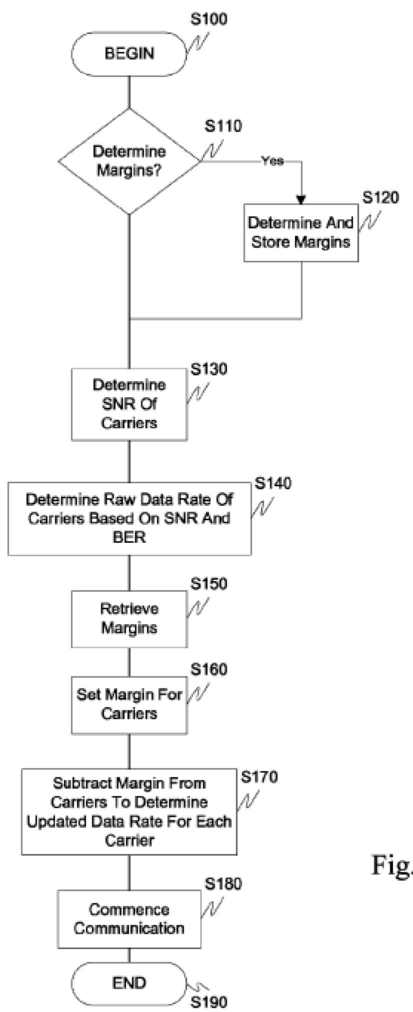

Fig. 2

'354 Patent, Fig. 2

54. First, the system decides if margins need to be determined. ’354 Patent at 8:7–13 (“S100”). If a margin needs to be determined, then the system determines the margins and stores them. *Id.* at 8:14–15 (“S120”). The SNR Margin of each carrier can have a certain margin assigned based on a particular environment impairment, including the length of the wire, temperature, and crosstalk. *Id.* at 5:7–10. “Having retrieved the margins for one or more of the carriers, the margins are set in the DMT system **30**. The margins can then be subtracted from the carrier to determine an updated data rate for each carrier. Having set the margins, and knowing the data rate, the DMT system can then commence communication over the communications link 10.” *Id.* at 8:1–6.

VI. LEVEL OF ORDINARY SKILL IN THE ART

55. I have been asked to offer my opinion regarding the level of ordinary skill in the art with respect to each of the Asserted Patents.

56. In my opinion, with regard to the Certain Family 2 Patents, Family 4 Patent, and the Family 10 Patents a person of ordinary skill in the art would have had a bachelor’s degree in electrical or computer engineering and 5 years of experience in telecommunications or a related field, a Master’s degree in electrical engineering and 2-3 years of experience in telecommunications or a related field, or a Ph.D. in electrical engineering with 1-2 years of experience in telecommunications or a related field. As of the time of the invention of the various patents and continuing through the present, I qualify as a person of ordinary skill in the art.

VII. DISPUTED CLAIM TERMS

57. I have been asked to provide opinions as to the terms and issues identified below and the claims associated with those terms.

A. Certain Family 2 Patents

1. "reduce a difference in latency between the bonded transceivers"

Claim(s)	Plaintiff's Position	Defendants' Position
'881 Patent, Claims 17, 25, 26, 29, 31, 33, 37	"reduce a difference in configuration latency"	Indefinite, or, if not indefinite, "minimize the difference in the configuration latencies between the bonded transceivers"

58. I understand that the parties dispute the construction of the phrase "reduce a difference in latency between the bonded transceivers," which is in the above-listed claims of the '881 Patent. I understand that the Plaintiff contends that this term means "reduce a difference in configuration latency." Having considered the parties' positions, I agree with Defendants' position that the term is indefinite. As I explain below, it is my opinion that a person having ordinary skill in the art would not understand what is meant by this term with reasonable certainty.

59. In my opinion, the word "reduce" is a word of degree—just like the converse word "increase" is a word of degree. To "reduce a difference in latency" necessarily requires a comparison of the reduced latency difference against some baseline latency. But, in my opinion, neither the specification nor the prosecution history provides any guidance from which a person of skill in the art could determine what it means to "reduce a difference in latency" to anything other than zero difference between configuration latencies.

60. While the specification identifies a variety of causes of latency, the specification does not illuminate what it means to "to reduce a difference in latency." To the contrary, the specification adds both subjectivity and uncertainty to the limitation. The '881 patent explains that the configuration latency of a transceiver can be calculated using an equation that involves the transmission parameters used by that transceiver. *See, e.g.*, '881 patent at col. 6:66-7:6

(configuration latency is the product of the number of bits in a codeword (N) and the interleaver depth in codewords (D) divided by the data rate in bits per second (R), i.e., N*D/R). Thus, a transceiver's configuration latency depends on the transmission parameters actually configured for that transceiver, and the data rate transmitted by that transceiver. The '881 patent presents its disclosure in the context of ADSL. As a person having ordinary skill as of the '881 patent's priority date would have understood, before the ADSL initialization procedure has been substantially completed, the data rate, R, is unknown. The transmission parameters are also determined during initialization but are not implemented until the transceiver transitions to steady-state communication. Without configured transmission parameters and a known data rate for the transceivers, there is no known configuration latency. Therefore, there is no configuration latency difference between two transceivers that can be known or determined until those two transceivers have been configured, i.e., until the initialization procedure has been substantially completed, the transmission parameters have been set, and the transmitters are transmitting at their respective established data rates R. The specification of the '881 patent does not disclose any way to reduce a difference in latency other than by configuring all transceivers' transmission parameters so that all transceivers have the same configuration latencies, thereby eliminating entirely any difference in configuration latency between the bonded transceivers. *See* '881 patent at col. 6:56-65 (describing reducing difference in latency by "mandat[ing] that all DSL PHYs are configured with transmission parameters in order to provide the same configuration latency."); col. 6:66-7:36 (calculating transmission parameters to provide the same configuration latency). For example, the patent does not disclose how to configure the transmission parameters to provide configuration latencies that are not identical, but nevertheless still "reduce a difference in latency." Aside from reducing the difference in configuration latency to zero, i.e., eliminating it

entirely, the ’881 patent does not describe any way that one of ordinary skill in the art would have known that a latency was reduced.

61. Indeed, it is possible to *increase* the difference in overall latency between two links by *reducing* the difference in configuration latency. Where one link’s wire latency is 10x greater than the second, utilizing transmission parameters to reduce only a difference in *configuration* latency could exacerbate the difference in overall latency, or leave it unchanged (*i.e.*, by bringing the configuration latencies close to one another, the 10x wire latency difference remains unresolved). If, however, the system was configured to reduce the difference in the *overall* latency as the claim reads, it would reduce configuration latency on the high-wire-latency link while increasing configuration latency on the low-wire-latency link—thereby reducing the overall difference in latency despite increasing the difference in configuration latency.

62. The prosecution history does not provide any guidance for how to reduce a difference in latency either. None of the claims of the ’881 Patent as originally submitted included a limitation related to reducing a difference in latency. *See* Application No. 10/264,258 (filed October 4, 2002), Claims. The limitation was introduced when the applicant cancelled all the original claims, and added new claims 13-70 ostensibly “to provide more comprehensive protection for certain aspects of the invention.” *See* February 28, 2007 Amendment, at pp. 4-13. After the applicant conducted an interview with the Examiner on March 15, 2007, the summary of which offers no specifics as to what was discussed, the Examiner allowed claims 13-28, again with no discussion of the limitation. Claims 29 and 30 became claims 17 and 18 of the ’881 patent.

63. The ’881 patent does not include any guidance that would allow a skilled artisan to determine with reasonable certainty whether a difference in latency has been “reduced”

between transceivers when their configuration latencies are not identical. For example, if one "bonded transceiver" has a configuration latency of 10 ms, and another has a configuration latency of 12 ms, does that mean a difference in latency has been reduced? The '881 patent provides no answer to this question.

64. In my opinion, therefore, to a person of skill in the art, the limitation "to reduce a difference in latency" lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.[3]

2. "each bonded transceiver utilizing at least one transmission parameter value to reduce a difference in latency between the bonded transceivers"

Claim(s)	Plaintiff's Position	Defendants' Position
'881 Patent, Claims 17, 25, 26, 29, 31, 33, 37	Plain and ordinary meaning. No construction necessary. The term "reduce a difference in latency between the bonded transceivers" means "reduce a difference in configuration latency"	Indefinite, or, if not indefinite, "each bonded transceiver configured with at least one transmission parameter value to minimize the difference in the configuration latencies between the bonded transceivers"

65. I understand that the parties dispute the construction of "each bonded transceiver utilizing at least one transmission parameter value to reduce a difference in latency between the bonded transceivers," which is in the above-listed claims of the '881 Patent. I understand that the Plaintiff does not offer a construction for this term but contends that the portion of the term "reduce a difference in latency between the bonded transceivers" be construed to mean "reduce a difference in configuration latency." Having considered the parties' positions, I agree with Defendants' position that the term is indefinite. For the same reasons provided above with

[3] Because I believe this term is indefinite, I do not offer an opinion on Defendants' proposed alternative construction.

respect to the term "reduce a difference in latency between the bonded transceivers," a person of skill in the art at the time of the alleged invention would not understand what is meant by the phrase "each bonded transceiver utilizing at least one transmission parameter value to reduce a difference in latency between the bonded transceivers."

66. In my opinion, therefore, to a person of skill in the art, the limitation "each bonded transceiver utilizing at least one transmission parameter value to reduce a difference in latency between the bonded transceivers" lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.[4]

3. "utilize at least one transmission parameter value, for each transceiver in a plurality of bonded transceivers, to reduce a difference in latency between the bonded transceivers"

Claim(s)	Plaintiff's Position	Defendants' Position
'881 Patent, Claims 33, 37	Plain and ordinary meaning. No construction necessary. The term "reduce a difference in latency between the bonded transceivers" means "reduce a difference in configuration latency"	Indefinite, or, if not indefinite, "configure at least one transmission parameter value of each bonded transceiver to minimize the difference in the configuration latencies between the bonded transceivers"

67. I understand that the parties dispute the construction of "utilize at least one transmission parameter value, for each transceiver in a plurality of bonded transceivers, to reduce a difference in latency between the bonded transceivers," which is in the above-listed claims of the '881 Patent. I understand that the Plaintiff does not offer a construction for this term but contends that the portion of the term "reduce a difference in latency between the bonded transceivers" be construed to mean "reduce a difference in configuration latency." Having

[4] Because I believe this term is indefinite, I do not offer an opinion on Defendants' proposed alternative construction.

considered the parties' positions, I agree with Defendants' position that the term is indefinite. For the same reasons provided above with respect to the term "reduce a difference in latency between the bonded transceivers," a person of skill in the art at the time of the alleged invention would not understand what is meant by the phrase "utilize at least one transmission parameter value, for each transceiver in a plurality of bonded transceivers, to reduce a difference in latency between the bonded transceivers."

68. In my opinion, therefore, to a person of skill in the art, the limitation "utilize at least one transmission parameter value, for each transceiver in a plurality of bonded transceivers, to reduce a difference in latency between the bonded transceivers" lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.[5]

4. "utilize at least one parameter associated with operation of at least one of the first and second transceivers to reduce a difference in latency between the first and second transceivers"

Claim(s)	Plaintiff's Position	Defendants' Position
'193 Patent, Claim 13 '601 Patent, Claims 14, 21	Plain and ordinary meaning. No construction necessary. The term "reduce a difference in latency between the bonded transceivers" means "reduce a difference in configuration latency"	Indefinite

69. I understand that the parties dispute the construction of "utilize at least one parameter associated with operation of at least one of the first and second transceivers to reduce a difference in latency between the first and second transceivers," which is in the above-listed claims of the '193 Patent and the '601 Patent. I understand that the Plaintiff does not offer a

[5] Because I find this term to be indefinite, I do not offer an opinion on Defendants' proposed alternative construction.

construction for this term but contends that the portion of the term "reduce a difference in latency between the bonded transceivers" be construed to mean "reduce a difference in configuration latency." Having considered the parties' positions, I agree with Defendants' position that the term is indefinite. For the same reasons provided above with respect to the term "reduce a difference in latency between the bonded transceivers," a person of skill in the art at the time of the alleged invention would not understand what is meant by the phrase "utilize at least one parameter associated with operation of at least one of the first and second transceivers to reduce a difference in latency between the first and second transceivers."

70. The additional disclosure added to the specification of the '193 and '601 patents does not provide any additional clarity as it similarly does not disclose any way to reduce a difference in latency other than by configuring all transceivers' transmission parameters so that all transceivers have the same configuration latencies, thereby eliminating entirely any difference in configuration latency between the bonded transceivers. *See, e.g.*, '193 patent at col. 11:3-13.

71. Likewise, the prosecution histories of the '193 and '601 patents do not provide any guidance for how to reduce a difference in latency either. None of the claims of either as originally submitted included a limitation related to reducing a difference in latency. *See* Application No. 14/465,502 (filed August 21, 2014), Claims; Application No. 14/682,435 (filed April 9, 2015), Claims. In the prosecution of the '193 patent, the applicant first canceled original claims 1-12 and added new claims 13-18 via a preliminary amendment. *See* September 26, 2014 Preliminary Amendment, at pp. 42-3. None of the newly added claims included the reduced latency limitation. In response to a rejection, the applicant conducted an interview with the Examiner on December 16, 2014, where the applicant apparently proposed an amendment to the pending claims that overcame the rejection. Subsequently, the applicant introduced the limitation

when it added new claims 19-27, without explanation, which the Examiner allowed, again without explanation. Claim 27 became claim 13 of the ’193 patent.

72. In the prosecution of the ’601 patent, the limitation was introduced when the applicant cancelled all the original claims and added new claims 13-33 without explanation. *See* February 28, 2007 Amendment, at pp. 4-13. After the applicant conducted an interview with the Examiner on November 19, 2015, the summary of which includes no mention of the latency reduction limitation, the Examiner allowed claims 13-33, again with no discussion of the limitation. Claims 26 and 33 became claims 14 and 21 of the ’601 patent.

73. As with the ’881 patent, the ’193 and ’601 patents do not include any guidance that would allow a skilled artisan to determine with reasonable certainty whether a difference in configuration latency has been “reduced” between transceivers when their configuration latencies are not identical.

74. In my opinion, therefore, to a person of skill in the art, the limitation “utilize at least one parameter associated with operation of at least one of the first and second transceivers to reduce a difference in latency between the first and second transceivers” lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.

B. Family 4 Patent

1. “multiple carrier signals corresponding to the scrambled carrier signals are used by the first multicarrier transceiver to modulate the same bit value” (identified by Defendants) / “same bit value” (identified by Plaintiff)

Claim(s)	Plaintiff’s Position	Defendants’ Position
’008 Patent, Claim 14	“a first carrier signal is used by the first multicarrier transceiver to demodulate the value of a bit of the received bit stream and at least one more carrier signal is used by the first multi carrier transceiver to demodulate the	Indefinite

	value of the same bit of the received bit stream, wherein the carrier signals correspond to the plurality of phase-shifted and scrambled carrier signals" / "a first carrier signal is used by the first multicarrier transceiver to modulate the value of a bit and at least one more carrier signal is used by the first multicarrier transceiver to modulate the value of the same bit, wherein the carrier signals correspond to the scrambled carrier signals"	

75. I understand that the parties dispute the construction of "multiple carrier signals corresponding to the scrambled carrier signals are used by the first multicarrier transceiver to modulate the same bit value" (identified by Defendants) / "same bit value" (identified by Plaintiff) which is in the above-listed claim of the '008 Patent. I understand that the Plaintiff contends that this term be construed to mean "a first carrier signal is used by the first multicarrier transceiver to demodulate the value of a bit of the received bit stream and at least one more carrier signal is used by the first multi carrier transceiver to demodulate the value of the same bit of the received bit stream, wherein the carrier signals correspond to the plurality of phase-shifted and scrambled carrier signals" / "a first carrier signal is used by the first multicarrier transceiver to modulate the value of a bit and at least one more carrier signal is used by the first multicarrier transceiver to modulate the value of the same bit, wherein the carrier signals correspond to the scrambled carrier signals." I understand that Defendants contend that the term is indefinite. Having considered the parties' positions, I agree with Defendants' interpretation.

76. It is my opinion that the limitation "multiple carrier signals corresponding to the scrambled carrier signals are used by the first multicarrier transceiver to modulate the same bit

value" (identified by Defendants) / "same bit value," when read in light of the specification and file history, does not inform a person of ordinary skill in the art, with reasonable certainty, of the scope of the invention. In other words, I believe a person of ordinary skill would find this limitation to be indefinite. The indefiniteness arises from the lack of clarity of whether the claim intends for the term "same bit value" to mean "same bit position" or whether it employs the different meaning ascribed to the term "bit value" in the specification.

77. A person of ordinary skill in the art could interpret "same bit value" in at least two ways. First, a person of ordinary skill could interpret "same bit value" to mean a particular bit in a series of bits, *i.e.*, a bit position. For example, the specification refers to the "same input data bits," stating that, an example of a case "where the phases of modulated carrier signals are not random [is] when . . . multiple carrier signals are used to modulate the same input data bits." '008 Patent at 2:16-19. Provisional Application 60/164,134, to which the Family 4 Patent claims priority, also refers to this concept in terms of "***same data bits***" rather than "***same bit value***." '134 Provisional at 1-2 (stating that improving phase randomization would be needed where "[t]he same data bits are used to modulate multiple carriers. This would occur in cases where it was desired (or required) to send the same data bits on different carriers and then combine the results at the receiver in order to receive the bits at a lower Bit Error Rate (this is a well-known method for using frequency diversity to decrease the BER)."). A person of skill in the art would understand both of these passages, which detail the problem the invention purportedly addresses, to mean repeating a portion of a bit stream on multiple carriers, or, as I described above, modulating the same bit position in a series of bits onto multiple carriers.

78. On the other hand, the specification generally and repeatedly uses the actual claim language "bit value" in a different sense. The specification discusses selecting a value for use in

computing the phase shift independently of “the bit value(s) modulated onto the carrier signal.” ’008 Patent at 4:50-53, 5:2-4 (“When the equation is independent of the bit values of the input serial bit stream 54, the computed phase shifts are also independent of such bit values.”); Abstract (“The value is determined independently of any bit value carried by that carrier signal.”); 2:39-40 (“The value is determined independently of any input bit value carried by that carrier signal.”). In these passages, a person of ordinary skill would understand that the specification is referring to the value (0 or 1) of any given bit, rather than the specific position of the bit in the bit stream.

79. The different meanings create uncertainty over claim scope. In the first meaning, the claim scope would be limited to instances in which specific portions of a bit stream are modulated on multiple carriers. But taking the meaning of bit value generally described in the specification, the scope of the claim would be much broader. Because the value of a bit can only be 0 or 1, once there are three or more carriers carrying only a single bit, at least two of them will be modulated by the same bit value (0 or 1). As the specification explains, there may be hundreds of carriers. ’008 Patent at 5:49-52. Thus, interpreting “same bit value” to refer to the value of a bit (0 or 1), the claim scope is broadened to include essentially any transmission. In contrast, modulating the same bits onto multiple carriers (for improved bit ratio or other reasons) would refer to a discrete and smaller set of transmissions. A person of ordinary skill in the art would understand that scrambling the phase characteristics of the carriers in both of these scenarios would be reasonable design goals. But, as described above, between the claim scope suggested by the problem that the invention purportedly addresses and the broader claim scope suggested by the meaning the specification otherwise ascribes to “bit value,” the specification fails to clarify what meaning ought to be ascribed to “same bit value” as used in the claims, and

thus a person of ordinary skill would not be reasonably certain of the claim scope.

80. The prosecution history does not provide any guidance regarding the meaning and scope of the term "same bit value" either. The claim that issued as claim 14 was examined as claim 53, and when that claim was first proposed via a preliminary amendment, the claim included the limitation "wherein multiple carrier signals are used to modulate the same bit value, and the value associated with the carrier signal is determined using a pseudo-random number generator." Applicant Arguments/Remarks Made in an Amendment dated Aug. 11, 2011 at 3. The applicant provided no reasoning for amending the claims and did not state where the specification provided support for the claims. Applicant Arguments/Remarks Made in an Amendment dated Aug. 11, 2011 at 6. The applicant amended claim 53 on October 3, 2011, such that the limitation was then in the same form as it was when it issued: "wherein multiple carrier signals corresponding to the scrambled carrier signals are used by the first transceiver to modulate the same bit value." Applicant Arguments/Remarks Made in an Amendment dated Oct. 3, 2011 at 5. The applicant also filed a terminal disclaimer to the patent resulting from Application No. 11/860,080, and the claims were allowed shortly thereafter. Notice of Allowance, Nov. 17, 2011 at 2. Thus, the prosecution history does not provide any guidance regarding the meaning and scope of the term "same bit value."

81. Plaintiff's proposed construction also does not clarify the meaning of the term "same bit value." First, despite the fact that the term identified for construction by Plaintiff is contained within the term identified for construction by Defendants, Plaintiff apparently interprets the broader term in the context of ***demodulation*** and interprets the narrower term in the context of ***modulation***. *See* Plaintiff's construction, *supra* ("a first carrier signal is used by the first multicarrier transceiver ***to demodulate*** the value of a bit of the received bit stream and at

least one more carrier signal is used by the first multi carrier transceiver ***to demodulate*** the value of the same bit of the received bit stream, wherein the carrier signals correspond to the plurality of phase-shifted and scrambled carrier signals" / "a first carrier signal is used by the first multicarrier transceiver ***to modulate*** the value of a bit and at least one more carrier signal is used by the first multicarrier transceiver ***to modulate*** the value of the same bit, wherein the carrier signals correspond to the scrambled carrier signals"). I see no reason for this difference, and I assume that this discrepancy in Plaintiff's proposed constructions is in error. Further, Plaintiff's construction does nothing to clarify whether "same bit value" should be understood according to either of the two interpretations discussed above, *i.e.*, whether "same bit value" should mean "same bit position" or instead should mean "same bit value, *i.e.*, 0 or 1." Instead Plaintiff's construction appears to utilize both understandings of the term, where Plaintiff's construction requires a first carrier signal to modulate "the value of a bit" (*i.e.*, 0 or 1) and another carrier signal to modulate "the value of the same bit." In this latter phrase, Plaintiff appears to be referring to both interpretations of the term—the value of the bit and the position of the bit. Plaintiff's construction therefore does not clarify the scope of the claim.

82. In my opinion, therefore, to a person of skill in the art, the limitation "multiple carrier signals corresponding to the scrambled carrier signals are used by the first multicarrier transceiver to modulate the same bit value" (identified by Defendants) / "same bit value" (identified by Plaintiff) lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence, the term is indefinite.

C. Certain Family 10 Patent

1. "A multicarrier communications transceiver operable to: receive a multicarrier symbol comprising a first plurality of carriers"

Claim(s)	Plaintiff's Position	Defendants' Position
'354 Patent,	Plain and ordinary meaning. No	Indefinite

Claim 10	construction necessary	

83. I understand that the parties dispute the construction of "[a] multicarrier communications transceiver operable to receive a multicarrier symbol comprising a first plurality of carriers," which is in asserted claim 10 of the '354 Patent. I understand that the Plaintiff contends that this term should be afforded its "[p]lain and ordinary meaning. No construction necessary." Having considered the parties' positions, I agree with Defendants' interpretation. As I explain below, it is my opinion that a person having ordinary skill in the art would not understand what is meant by this term with reasonable certainty.

84. The specification of the '354 Patent does not disclose or define a "multicarrier symbol." The specification shows that the alleged invention relates to a discrete multitone modulation system. *See, e.g.*, '354 Patent at 1:30–2:45, 4:14–16 ("In an exemplary embodiment of the invention, the margin is set to be different on at least two subchannels in a discrete multitone modulation system."). Therefore, in this context, a person of ordinary skill in the art would understand a "multicarrier symbol" to refer to a symbol used in a discrete multitone modulation system, which is the sum of the full collection of carriers modulated by the system. It is unclear to a person of ordinary skill in the art how a multicarrier symbol is subdivided into a first and a second plurality of carriers. Furthermore, it is unclear to a person of ordinary skill in the art how a multicarrier symbol could comprise a subset of carriers from the full collection such that there could be a first plurality of carriers and a second plurality of carriers.

85. Nor does the prosecution history provide any guidance on this term. The applicant cancelled claims 2–45 in the preliminary amendment, leaving claim 1 as the only claim in the application. *See* '354 Prosecution History, January 7, 2015 Preliminary Amendment at 3. None

of the original claims included a reference to a "symbol" or a "multicarrier symbol." *See id.* '354 Prosecution History, January 7, 2015 Preliminary Amendment, Claims. Subsequently, a Non-Final Rejection based on nonstatutory obviousness-type double-patenting and anticipation was sent to the applicant. *See* February 9, 2015 Non-Final Rejection at 3–5. In response, the applicant canceled claim 1 and added claims 46–57, some of which reference a "multicarrier symbol." *See* May 14, 2015 Amendment, Claims. Based on this amendment, the Examiner allowed claims 46–57 and stated that the "[c]laims are allowed over prior art of record because the cited references either singularly or in combination cannot teach or suggest uniquely distinct features used in combination with other claimed elements '*transmitting/receiving a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers*' as set forth in the application claims 46, 49, 52 and 55," with no further discussion of this limitation. July 29, 2015 Notice of Allowance at 2 (emphasis in original). Claim 55 became claim 10 of the '354 Patent.

86. In my opinion, a person of ordinary skill in the art would find that the limitation, "[a] multicarrier communications transceiver operable to receive a multicarrier symbol comprising a first plurality of carriers" lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.

2. "receive a first plurality of bits on the first plurality of carriers using a first SNR margin; receive a second plurality of bits on the second plurality of carriers using a second SNR margin"

Claim(s)	Plaintiff's Position	Defendants' Position
'354 Patent, Claim 10	Plain and ordinary meaning. No construction necessary	Indefinite

87. I understand that the parties dispute the construction of "receive a first plurality of bits on the first plurality of carriers using a first SNR margin; receive a second plurality of bits

on the second plurality of carriers using a second SNR margin," which is in claim 10 of the '354 Patent. I understand that the Plaintiff contends that this term should be afforded its "[p]lain and ordinary meaning. No construction necessary." Having considered the parties' positions, I agree with Defendants' interpretation because the Plaintiff's construction contradicts the specification's description of the relationship between the plurality of carriers and the SNR margin assigned to the plurality of carriers. As I explain below, it is my opinion that a person having ordinary skill in the art would not understand what is meant by this term.

88. The specification of the '354 Patent does not disclose or define "receive a first plurality of bits on the first plurality of carriers using a first SNR margin; receive a second plurality of bits on the second plurality of carriers using a second SNR margin." Based on the specification, a person of skill in the art would understand that in the context of the '354 Patent, an SNR margin is assigned to a carrier. *See* '354 Patent at 3:27–33, 4:10–11; 5:20–24, 9:22–24. The specification does not describe any other connection between a SNR margin and a carrier, such as how the plurality of carriers use a SNR margin to "receive a [first/second] plurality of bits."

89. During initialization of the discrete multitone modulation system, the signal-to-noise ratios of each subchannel is calculated by the system by sending signals between the transmitter and receiver. Then, the system calculates the number of bits that can be transmitted on each subchannel, in part, by using the calculated signal-to-noise ratios of each subchannel. A person of ordinary skill in the art would not understand how the transmitter could "receive a [first/second] plurality of bits . . . using a [first/second] SNR margin" when the SNR margin is used by the transmitter during initialization to determine the number of bits to transmit on each subchannel. Nor could a person of ordinary skill in the art understand how the SNR margin, as

assigned to the plurality of carriers, is used to "receive a [first/second] plurality of bits." Based on the '354 Patent specification, a person of skill in the art would understand that the SNR margin is assigned to the plurality of carriers based on impairments of or on a carrier, such as insertion loss of the wire or medium itself, or based on a known impairment on a carrier. *See* '354 Patent at 2:14–19; 5:3–6; 7:29–36. Accordingly, the SNR margin is not used to receive a plurality of bits.

90. Nor does the prosecution history provide any guidance on this term. The applicant cancelled claims 2–45 in the preliminary amendment, leaving claim 1 as the only claim in the application. *See* '354 Prosecution History, January 7, 2015 Preliminary Amendment at 3. Subsequently, a Non-Final Rejection based on nonstatutory obviousness-type double-patenting and anticipation was sent to the applicant. *See* February 9, 2015 Non-Final Rejection at 3–5. In response, the applicant canceled claim 1 and added claims 46–57, some of which include this term. *See* May 14, 2015 Amendment, Claims. Based on this amendment, the Examiner allowed claims 46–57 and stated that the "[c]laims are allowed over prior art of record because the cited references either singularly or in combination cannot teach or suggest uniquely distinct features used in combination with other claimed elements '*<u>transmitting/receiving a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers</u>*' as set forth in the application claims 46, 49, 52 and 55," with no further discussion of this limitation or any other limitation. July 29, 2015 Notice of Allowance at 2 (emphasis in original). Claim 55 became claim 10 of the '354 Patent.

91. In my opinion, a person of ordinary skill in the art would find that the limitation, "receive a first plurality of bits on the first plurality of carriers using a first SNR margin; receive a second plurality of bits on the second plurality of carriers using a second SNR margin" lacks

any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.

3. "wherein the first SNR margin provides more robust reception than the second SNR margin"

Claim(s)	Plaintiff's Position	Defendants' Position
'354 Patent, Claim 10	Plain and ordinary meaning. No construction necessary	Indefinite

92. I understand that the parties dispute the construction of "wherein the first SNR margin provides more robust reception than the second SNR margin," which is in the above listed claims of the '354 Patent. I understand that the Plaintiff contends that this term should be afforded it "[p]lain and ordinary meaning. No construction necessary." Having considered the parties' positions, I agree with Defendants' position.

93. The specification of the '354 patent does not disclose or define this term in relation to specific carriers. The specification refers to robustness as a tradeoff with data rate for the whole system, not individual carriers. *See* '354 Patent at 2:17–33 ("DMT transceivers use a margin to increase the system's immunity to various types of time varying impairments. . . .When a DMT system is operating with a positive SNR margin, the noise can change instantaneously by the level of the margin and the system will still maintain the required BER. . . . Obviously the penalty for this increase in robustness is a decrease in the data rate, since with a 0 dB margin, a subchannel with 27.5 dB SNR can modulate 6 bits at 1×10^{-7} BER.").

94. Moreover "robustness" of a signal can be measured in a number of different ways. The specification lists some of these as advantages of multicarrier modulation, for example, "a higher immunity to impulse noise, a lower complexity equalization requirement in the presence of multipath, a higher immunity to narrow band interference, a higher data rate and bandwidth

flexibility." '354 Patent at 1:45–49. Each of these provides what a person of ordinary skill in the art would understand as a measure of robustness, i.e., the ability to maintain a specified quality of operation under uncertain or changing operating assumptions. In this scenario, all of these measures would be related to reception, but it is unclear how each would necessarily be "provided for" by SNR margin. This term requires that "the first SNR margin ***provides*** more robust reception." A person of ordinary skill in the art would not understand how an SNR margin could provide more robust reception because, as explained above, robustness can be measured in multiple ways and a particular carrier could be "more robust" than a second carrier for a factor other than the SNR margin.

95. Nor does the prosecution history provide any guidance on this term. The applicant cancelled claims 2–45 in the preliminary amendment, leaving claim 1 as the only claim in the application. *See* '354 Prosecution History, January 7, 2015 Preliminary Amendment at 3. Subsequently, a Non-Final Rejection based on nonstatutory obviousness-type double-patenting and anticipation was sent to the applicant. *See* February 9, 2015 Non-Final Rejection at 3–5. In response, the applicant canceled claim 1 and added claims 46–57, some of which include this term. *See* May 14, 2015 Amendment, Claims. Based on this amendment, the Examiner allowed claims 46–57 and stated that the "[c]laims are allowed over prior art of record because the cited references either singularly or in combination cannot teach or suggest uniquely distinct features used in combination with other claimed elements '<u>*transmitting/receiving a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers*</u>' as set forth in the application claims 46, 49, 52 and 55," with no further discussion of this limitation or any other limitation. July 29, 2015 Notice of Allowance at 2 (emphasis in original). Claim 55 became claim 10 of the '354 Patent.

96. In my opinion, a person of ordinary skill in the art would find that the limitation, "wherein the first SNR margin provides more robust reception than the second SNR margin" lacks any certainty as to its meaning or scope, let alone reasonable certainty, and hence renders the claims indefinite.

I declare under penalty of perjury that the foregoing is true and correct. Executed this 14th day of March, 2022.

George A. Zimmerman, Ph.D.

EXHIBIT A

List of Materials Considered

- U.S. Patent No. 7,453,881
- U.S. Patent No. 9,014,193
- U.S. Patent No. 9,300,601
- U.S. Patent No. 8,090,008
- U.S. Patent No. 9,154,354
- U.S. Patent No. 8,937,988
- File History of U.S. Patent No. 7,453,881
- File History of U.S. Patent No. 9,014,193
- File History of U.S. Patent No. 9,300,601
- File History of U.S. Patent No. 8,090,008
- File History of U.S. Patent No. 9,154,354
- File History of U.S. Patent No. 8,937,988
- Provisional Application No. 60/164,134
- Provisional Application No. 60/197,727
- G.992.1- ITU
- G.993.2- ITU
- G.997.1- ITU

EXHIBIT B

George A. Zimmerman
(310) 920-3860 (mobile/business)
george@cmephyconsulting.com
1430 9th Street
Manhattan Beach, CA 90266

SUMMARY

High-technology leader with proven combination of technology & business leadership for advanced technologies including development of core technology, licensing, strategy development, standardization, partnerships, strategic alliances, mergers & acquisitions. Recognized expert in broadband communications, physical-layer wireline technology and interference management techniques.

EXPERIENCE

President & Principal Consultant, CME Consulting, Inc. (5/11 - present)
Independent consultant on high-performance communications technology and solutions, specializing in wireline communications. Consulting on next generation technologies, technology development, standards, intellectual property, and business development. Example engagements include:

- Multi-gigabit video/home networking PHY feasibility study
- 25G, 40GBASE-T, and 50GBASE-T design feasibility studies with current and existing cabling
- 25Gbps Ethernet architectures, design feasibility and standardization
- Next Generation structured cabling architecture and applications
- Automotive Gigabit Ethernet PHY architecture design and analysis
- Single pair Ethernet PHY architecture design and analysis (including cabling and powering)
- 4 Pair Power over Ethernet standardization and applications
- Business planning for new market developments in wireline technologies
- Standards strategy and consulting
- Standards guidance, representation and sheparding
- Litigation support services, including testifying expert in patent infringement actions

Consulting Clients include:

- Silicon Image, Inc. (6/11 – 9/11) (a designer and manufacturer of HDMI video chipsets)
- Commscope, Inc. (5/11 – current) (a designer and manufacturer of cabling systems, including LAN cabling)
- Nexans, Inc. (4/12 – 8/12) (a designer and manufacturer of cabling systems, including LAN cabling)
- Aquantia, Inc. (2/13 – 12/19) (a designer and manufacturer of 10Gbps and Automotive Ethernet chipsets)
- Marvell Semiconductor (12/19 – current) (a designer and manufacturer of Ethernet chipsets – acquired Aquantia in 12/19)
- BMW Group (1/17 – 11/19) (a designer and manufacturer of automobiles) through Technica Engineering, and (6/13 – 3/14) through Berner & Mattner AG;
- Linear Technology Corporation (8/14- 3/17) (a designer and manufacturer of high performance analog integrated circuits, including Power over Ethernet controllers)
- Cisco Systems (11/15-current) related to Power over Ethernet technology, and power & data in general
- Analog Devices (1/17-current), related to IEEE 802.3 standards for single-pair 10Mb/s Ethernet
- APL Group (a consortium including Rockwell Automation, Siemens, Pepperl+Fuchs, Endress-Hauser, focused on industrial networking) (3/17-current), related to the single-pair Ethernet for industrial applications.
- See below under "Litigation Support Experience" for expert witness engagements

Board Member, NBASE-T Alliance (2/2016 – 5/2019)
The NBASE-T Alliance (http://www.nbaset.org) focuses on building the ecosystem and consensus required to enable a new 2.5GBASE-T/5GBASE-T Ethernet standard. Working with key stakeholders, the consortium releases

specifications that define 2.5 and 5 Gigabit per second (Gbps) speeds at up to 100 meters using the large, installed base of copper cabling in enterprise networks. More than 35 companies have joined the alliance, representing all major facets of enterprise networking infrastructure such as access points, Ethernet switching, and computing, as well as the necessary technologies required to deliver these applications including physical layer ICs (PHYs), processors, connectors, controllers, switches, FPGAs, Power-over-Ethernet ICs, cables and test equipment. The alliance was founded in 2014 by Aquantia, Cisco, Freescale and Xilinx.

Technical Committee Chair, Ethernet Alliance (12/2015 – present)
The Ethernet Alliance (http://www.ethernetalliance.org) is a global, non-profit, industry consortium of member organizations that are dedicated to the continued success and advancement of Ethernet technologies. Members include system and component vendors, industry experts, and university and government professionals. Ethernet Alliance members work together to take Ethernet standards to the marketplace. They support and originate activities that span from incubation of new Ethernet technologies to interoperability testing to demonstrations to education.

Chief Technical Officer, SolarFlare Communications, Irvine, CA (1/01 – 5/11)
CEO, Solarflare Communications, Irvine, CA (5/02 – 5/03)
Member, Board of Directors, SolarFlare Communications, Irvine, CA (1/01 – 9/04)

- *Technical Leadership:* Technology visionary and founder of next-generation physical-layer communications fabless semiconductor company. Conceived and developed core technology, and led team to develop worlds-first 10GBASE-T 10 Gigabit Ethernet over Cat5e and Cat6 cabling. Developed industry ecosystem and standards for IEEE 802.3an (10GBASE-T) and energy-efficient version (IEEE 802.3az). Responsible for 8 key issued US patents (additional pending). Initiated and led IEEE 802.3an 10GBASE-T standards process to completion, with numerous technical contributions. Demonstrated world's first 10 Gigabit Ethernet link over 50m of Category 5e and Category 6 copper cabling (2004). Led team to develop silicon & demonstrate world's first standard (802.3an) compliant 10GBASE-T link over 100m Cat6a cabling (2006). Led 802.3az "Energy Efficient Ethernet" standards development, contributing key PHY expertise to develop low power idle concepts.

- *Business Leadership:* Created business plan resulting in Series A funding from Foundation Capital and Sequoia Capital (March 2001). Recruited, built and led early development team consisting of systems engineers, digital and analog VLSI designers for a CMOS COT process. Successfully built out initial management team to add VP of Engineering and VP of Sales and led company to initial product. As CEO, raised Series B funding in an oversubscribed up round (October 2002). Recruited replacement interim CEO and later current CEO, Russell Stern in fall 2003.

Member, Board of Directors, Aktino Corporation, Irvine, CA (5/03 – 5/05)
Advisory Board, Aktino Corporation, Irvine, CA (5/05-5/09)
Focused vision and helped prepare initial business plan which was successfully funded. Outside member of board of directors, and advisor to founding team of Telecommunications startup based on multi-wire physical-layer communications technology. As member of board of directors, advised on first 2 years of company's development. Stepped off board after successful Series B round, continued to serve as an advisor on standards, technology and early business issues.

Vice President of Strategic Planning, PairGain Technologies, Tustin, CA (4/99 – 6/00)
Chief Scientist, PairGain Technologies, Tustin, CA (5/95 – 6/00)
Responsible for technology strategy, wireline technology origination and standardization, new business development and technology marketing in $280M/yr (1998) DSL networking systems market leader, including:

- *Technology strategies & new technology developments.* Conception, definition and execution of corporate new technology strategies. Accomplishments include:
  ➢ *ADSL/G.lite*: Authored corporate G.lite/DMT ADSL technology strategy, negotiated technology licenses and managed PairGain's Universal ADSL Working Group (UAWG) and ITU-T G.lite efforts;
  ➢ *HDSL2*: Definition and execution of 3+ year corporate strategy for HDSL2 single-pair T1 technology development and technology transition from 2-pair HDSL. Invented HDSL2-standard OPTIS transmission scheme allowing single-pair transmission of 1.5Mbps data at the same quality as 2-pair HDSL, formed OPTIS coalition and drove ANSI HDSL2 standard (T1.418) incorporating PairGain's technology;

- *Intellectual Property Management & Licensing.* Developed and negotiated technology and patent licensing agreements, including both IPR licenses to PairGain and PairGain licenses of third party IPR. Defined and executed DMT ADSL licensing to Rockwell Semiconductor Systems;
- *Technology Standardization.* Represent PairGain in xDSL standardization activities, personally authoring technical guidelines for spectral compatibility for xDSL systems (T1.417-2000), and driving the development of HDSL2 technology (T1.418-2000). Contributing member of ITU-T Study Group 15/Q4 (driving G.991 & G. 992, including G.dmt, G.lite and G.shdsl), Universal ADSL Working Group (UAWG) and ANSI-Accredited Committee T1E1.4. Contributing member of Home Phone line Networking Alliance (HomePNA).
- *Corporate strategy & business development.* Key driver in execution of sale of microelectronics group to Globespan technologies for $346 million at closing. Recommended corporate alliance or merger for improving shareholder value & success factors in DSL networking - company merged with ADC for $2.7B in June 2000;
- *Corporate presentations:* frequent speaker at market forums, financial conferences, and technology forums;

Lecturer, California Institute of Technology, Pasadena, CA (4/92-6/94)

Ph.D. Advisor to Michael J. Flanagan following Edward Posner's death, 7/93-6/94
Introduction to Linear Systems: Fall 1993, Winter 1994
Communications Systems Fundamentals: Spring 1992, 1993 and 1994

Member of Technical Staff, Jet Propulsion Laboratory, Pasadena, CA (7/85-5/95)

Management and team leadership in signal processing and communications research and development. Research, development, design and analysis of innovative signal processing algorithms and architectures for digital and mixed-signal systems and ASICs. Advanced development project and proposal leadership and presentation of new systems to internal and external customers.
Successful proposals include:

- Tiny Transponder, an ultra-miniature coherent spacecraft radio with 10 custom ASICs & MMICs ($9M),
- Channelized Signal Processor, a 4 megachannel digital filter bank and programmable processor ($2.2M)
- Sky Survey Signal Processor, a multimegachannel digital spectrum analyzer and CW detector ($12M),
- Spur-reduced DDS research and proof-of-concept ($ 300 k), and High-linearity D/A conversion research and proof-of-concept ($ 250 k).

Work Area Manager: Deep Space Network (DSN) Signal Processing Work Area.
Managed work area for research and development in advanced signal processing for NASA's DSN. Technical and fiscal management of work units within work area. Responsible for schedule and budget planning and performance, on $900 K annual budget reporting to NASA headquarters program manager.

Work Unit Leader: VLSI Applications Work Unit.
Technical, budgetary & schedule team leadership of research and development activities in VLSI algorithms and architectures. Research results include low-complexity, spur-reduced direct digital frequency synthesis, and dynamic element matching D/A converters, and proved in prototype hardware.

Systems Engineer / Architect / Analyst for NASA SETI Sky Survey (aka High Resolution Microwave Survey (HRMS)). Technical, schedule and review responsibility for large system definition including antennas, receivers, digital signal processing hardware and software for searching for extraterrestrial intelligent signals (SETI). Specific duties included program-planning, signal processing algorithm research, design option analysis, performance analysis, functional requirements definition and reviews. Authored and presented successful proposal for the HRMS signal processing hardware, and developed innovative signal-processing approaches to increase performance while reducing cost (> $2 M reduction).

Consulting Engineer on development of a high-speed, constraint length 15 Viterbi decoder. Advised on program planning and evaluation of design and architecture options.

Project Engineer on a Government project at JPL involving mixed signal processing algorithm research and demonstration. Designed digital signal processing boards comprising a digital spectrum analyzer, specified and designed system interfaces, and integrated system (IF-digital-software). Developed, tested and analyzed performance of algorithms in the lab and in the field.

Digital Design Engineer for an Advanced Digital SAR (Synthetic Aperture RADAR) Processor, the primary SAR data processor for the Magellan mission to Venus.

Independent Consultant, self-employed (1989-1995)
Communications and signal processing analysis, simulation and specification. Algorithmic, architectural and bit-level definition and simulation of mixed-signal ASICs and systems; including delta-sigma A/D and D/A converters and filters, error correction coding, audio compression and spread-spectrum communications networks.

Technician, GALIL Motion Control, Mountain View, CA (2/85-6/85)
Built, tested and troubleshot prototype and production digital motion control circuits.

Technical Intern, NCR Corp., Engineering & Manufacturing, San Diego, CA (6/84-9/84)
Improved clock synchronization and distribution for a modular, multi-board parallel processing unit.

Computer Programmer, St. Francis Medical Center, Lynwood, CA (6-9/83, 6-9/81, 6-9/80)
Created and maintained structured COBOL programs.

LITIGATION SUPPORT EXPERIENCE

Expert Engagement: (USITC Successfully Resolved 3/2012)
Type of Matter: Patent Infringement (testifying expert, wrote reports & rebuttals, deposition taken)
Law Firm: Kirkland & Ellis, LLP
Case Name: Cisco Systems, Inc. v. MOSAID Technologies, Inc, USITC Investigation No. 337-TA-778
Services Provided: Testifying Expert for Cisco (respondent)
Continuing Retention in Delaware District Case

Expert Engagement: (Closed, District of Delaware, 8/2013-4/2014)
Type of Matter: Patent Infringement (testifying expert, wrote declaration)
Law Firm: Kirkland & Ellis, LLP
Case Name: Cisco Systems, Inc. v. MOSAID Technologies, Inc, C.A. No. 10-687-GMS
Services Provided: Testifying Expert for Cisco (respondent) (continued district case related to previous ITC matter)

Expert Engagement: (USITC Successfully Resolved 7/2012)
Type of Matter: Patent Infringement (lead expert, wrote reports & rebuttals, deposition taken, settled before trial)
Law Firm: Kirkland & Ellis, LLP; McDermott, Will & Emery, LLP; Crowell & Moring, LLP
Case Name: Cisco, HP, Extreme Networks, Avaya v. Chrimar Systems, Inc, - USITC Investigation No. 337-TA-817
Services Provided: Testifying Expert for Cisco, HP, Extreme Networks, and Avaya (respondents)
Continuing Retention in Northern District of California Case

Expert Engagement: (Closed, Northern District of California, - 9/2019)
Type of Matter: Patent Infringement (expert, presented tutorial in court – awaiting further scheduling)
Law Firm: Kirkland & Ellis, LLP;
Case Name: Chrimar Systems, Inc. et. al. v. Cisco Systems Inc., et. al., No. C 13-01300 JSW Services Provided: Testifying Expert for Cisco (respondents), (continued district case related to previous ITC matter)

Expert Engagement: (Inactive/Stayed, 8/2012- 12/2016)
Type of Matter: Patent Infringement
Law Firm: Crowell & Moring, LLP, Winston & Strawn, LLP
Case Name: Network-1 Security Solutions, Inc. v. Alcatel-Lucent USA Inc. et. al., Case No. 6:11-cv-00492-LED (E.D. Tex.), Including US Patent and Appeals Board CASE IPR2013-00071
Services Provided: Consulting Expert for Respondents Avaya & Dell, Testifying Expert in IPR matter, Consulting Expert for Avaya in primary case.

Expert Engagement: (Closed, Western District of Texas, Austin Division,3/2013-4/2016)
Type of Matter: Patent Infringement
Law Firm: Dechert, LLP
Case Names: Intellectual Ventures II LLC v. AT&T, CenturyLink & Windstream), Civil Action No. 1:13-CV-00116-LY (Lead case)
Services Provided: Consulting Expert for Plaintiff Intellectual Ventures II, expert reports and deposition.

Expert Engagement: (Active 7/2017-)
Type of Matter: Patent Infringement
Law Firm: Bradley Arant Boult Cummings, LLP
Case Name: TQ Delta LLC v. ADTRAN Inc., Case No. 1:14-cv-00954-RGA
Services Provided: Consulting Expert, expert declarations, deposition testimony.

EDUCATION

California Institute of Technology, Pasadena, CA. MS Electrical Engineering '88, Ph.D. '90.
Doctoral study on interference cancellation for multi-access communications. Information theoretically motivated, developed and analyzed new interference-canceling receivers for use in multi-access FM communications. Tested receivers in simulation on fading channels demonstrating considerable improvement in frequency reuse for analog FM cellular telephony. Extensive patent filed based on thesis. Advisor: Dr. Edward C. Posner.

Stanford University, Palo Alto, CA. BS Electrical Engineering '85.

RESEARCH INTERESTS

- High-performance wireline transmission and applications
- Energy-efficient networking
- Applied signal processing for high-performance and multi-access communications
- Quantization and coding theory in signal processing systems

PATENTS

- U.S. Patent No. 11,061,456, TRANSMISSION OF PULSE POWER AND DATA OVER A WIRE PAIR, C. Jones, J. Goergen, G. Zimmerman, July 13, 2021.
- U.S. Patent 10,754,409, ENERGY EFFICIENT ETHERNET WITH MULTIPLE LOW-POWER MODES, S. Benyamin, P. Langer, G. Zimmerman, August 25, 2020.
- U.S. Patent No. 10,790,997, TRANSMISSION OF PULSE POWER AND DATA IN A COMMUNICATIONS NETWORK, C. Jones, J. Goergen, G. Zimmerman, R. O'Brien, D. Arduini, J. Potterf, S. Baek, September 29, 2020.
- U.S. Patent No. 10,291,285, METHODS FOR PERFORMING MULTI-DISTURBER ALIEN CROSSTALK LIMITED SIGNAL-TO-NOISE RATIO TESTS, B. Boban and G. Zimmerman, November 4, 2016.
- U.S. Patent No. 9,883,457, METHOD AND APPARATUS FOR REDUCING POWER CONSUMPTION OF A COMMUNICATIONS DEVICE DURING PERIODS IN WHICH THE COMMUNICATIONS DEVICE RECEIVES IDLE FRAMES FROM ANOTHER COMMUNICATIONS DEVICE, G. Zimmerman, March 16, 2015.
- US. Patent No. 8,984,304: ACTIVE IDLE COMMUNICATION SYSTEM, G. Zimmerman, November 12, 2007.
- U.S. Patent No. 8,912,934: SYSTEMS WITH BIAS OFFSET AND GAIN MISMATCH REMOVAL FROM PARALLEL TRANSMITTED SIGNALS, G. Zimmerman and W. Jones, December 16, 2014.
- U.S. Patent No. 8,743,674: FREQUENCY DOMAIN ECHO AND NEXT CANCELLATION, G. Parnaby, G. Zimmerman, C. Pagnanelli, W. Jones, June 3, 2014.
- U.S. Patent No. 8,363,535: FREQUENCY DOMAIN ECHO AND NEXT CANCELLATION, G. Parnaby, G. Zimmerman, C. Pagnanelli, W. Jones, January 29, 2013.
- U.S. Patent No. 8,294,606: SUB-CHANNEL DISTORTION MITIGATION IN PARALLEL DIGITAL SYSTEMS, G. Zimmerman and W. Jones, October 23, 2012.

- U.S. Patent No. 7,808,407: SUB-CHANNEL DISTORTION MITIGATION IN PARALLEL DIGITAL SYSTEMS, G. Zimmerman and W. Jones, October 5, 2010.
- U.S. Patent No. 7,742,386: MULTIPLE CHANNEL INTERFERENCE CANCELLATION, W. Jones and G. Zimmerman, June 22, 2010.
- U.S. Patent No. 7,567,666: METHOD AND APPARATUS FOR CROSSTALK MITIGATION, G. Zimmerman and W. Jones, July 28, 2009.
- U.S. Patent No. 7,352,687: MIXED DOMAIN CANCELLATION, W. Jones, G. Zimmerman and C. Pagnanelli, April 1, 2008.
- U.S. Patent No. 7,257,181: METHOD AND APPARATUS FOR CHANNEL EQUALIZATION, W. Jones and G. Zimmerman, August 14, 2007.
- U.S. Patent No. 7,164,764: METHOD AND APPARATUS FOR PRECODE CROSSTALK MITIGATION, G. Zimmerman and W. Jones, January 16, 2007.
- U.S. Patent No. 7,002,897: MULTIPLE CHANNEL INTERFERENCE CANCELLATION, W. Jones and G. Zimmerman, February 21, 2006.
- U.S. Patent No. 6,912,208: METHOD AND APPARATUS FOR JOINT EQUALIZATION AND CROSSTALK MITIGATION, G. Zimmerman and W. Jones, June 28, 2005..
- U.S. Patent No. 5,459,680: METHOD AND APPARATUS FOR SPUR-REDUCED DIGITAL SINUSOID SYNTHESIS, G. Zimmerman and M. Flanagan, October 17, 1995.
- U.S. Patent No. 5,068,859: LARGE CONSTRAINT LENGTH HIGH SPEED VITERBI DECODER BASED ON A MODULAR HIERARCHICAL DECOMPOSITION OF THE DeBRUIJN GRAPH, by O. Collins, et al, November 26, 1991.
- E.U. Patent No. EP2015454B1: SUB-CHANNEL DISTORTION MITIGATION IN PARALLEL DIGITAL SYSTEMS, G. Zimmerman and W. Jones, June 15, 2007.
- E.U. Patent No. EP1632048B1: METHOD AND APPARATUS FOR EQUALIZATION AND CROSSTALK MITIGATION, G. Zimmerman and W. Jones, May 16, 2003.
- E.U. Patent No. EP1625668B1: MULTIPLE CHANNEL INTERFERENCE CANCELLATION, W. Jones, G. Zimmerman, and C. Pagnanelli, April 22, 2004.
- E.U. Patent No. EP2255453B1: FREQUENCY DOMAIN ECHO AND NEXT CANCELLATION, G. Parnaby, G. Zimmerman, and W. Jones, February 29, 2008.
- E.U. Patent No. EP2503704B1: METHOD AND APPARATUS FOR EQUALIZATION AND CROSSTALK MITIGATION, G. Zimmerman, and W. Jones, May 16, 2003.

SELECTED PAPERS AND CONTRIBUTIONS

Gergely Huszak, Hiroyoshi Morita, George Zimmerman, "Backward-Compatible Forward Error Correction of Burst Errors and Erasures for 10BASE-T1S", IEICE Transactions on Communications, Vol. E104-B, No. 12, December 1, 2021, pp. 1524-1538 DOI: 10.1587/transcom.2021EBP3016.

Ernie Gallo & George A. Zimmerman, "Power over Ethernet: An Emerging Old Technology", ISE Magazine, https://www.isemag.com/2018/03/emerging-old-technology/, March 2018.

Marek Hajduczenia, Steven B. Carlson, Dan Dove, Mark Laubach, David Law, George A. Zimmerman, "Evolution of Ethernet Standards in IEEE 802.3 Working Group", IEEE Standards University, http://www.standardsuniversity.org/e-magazine/august-2016-volume-6/evolution-ethernet-standards-ieee-802-3-working-group/ , August 16, 2016.

George. Zimmerman and David Chalupsky, "Defining today's BASE-T Application Space", Cabling Installation and Maintenance Magazine, http://www.cablinginstall.com/articles/2016/05/ethernet-alliance-base-t-applications.html , May 2, 2016.

George. Zimmerman and David Chalupsky, "The Spaces of BASE-T", Ethernet Alliance whitepaper, http://www.ethernetalliance.org/wp-content/uploads/2016/04/BASE-TSpaces_EA_FINAL-041816.pdf , April 18, 2016.

George Zimmerman, “Proposed changes to support 2.5GBASE-T and 5GBASE-T”, IEEE P802.3bt 4 Pair Power via MDI Task Force Contribution, http://www.ieee802.org/3/bt/public/mar16/zimmerman_3bt_01a_0316.pdf , March 15, 2016.

G.A. Zimmerman, “Impact of length-scaling on worst-case NEXT for 30m channels”, IEEE P802.3bq 40GBASE-T Task Force Contribution, http://www.ieee802.org/3/bq/public/nov13/zimmerman_3bq_01a_1113.pdf, November 12, 2013.

G.A. Zimmerman, “Evaluating Power Sensitivity for Channel Impairments”, IEEE 802.3 Next Generation BASE-T Study Group Contribution, http://www.ieee802.org/3/NGBASET/public/mar13/zimmerman_01_0313_NGBT.pdf, March 15, 2013.

G.A. Zimmerman, “Relative Power Estimates for 40GBASE-T over 25m and 30m on Category 8”, IEEE 802.3 Next Generation BASE-T Study Group Contribution, http://www.ieee802.org/3/NGBASET/public/jan13/zimmerman_01a_0113_NGBT.pdf , January 22, 2013.

G.A. Zimmerman, “Complexity, Utility, and Energy Efficiency for Copper Ethernet at 10Gb/s and Beyond”, ISSCC ATAC High Speed Interfaces Forum, February 2009.

G.A. Zimmerman, “Challenges for 10Gb/s Implementation on UTP Media”, IEEE LEOS High Speed Interconnect Workshop, May 2006.

G.A. Zimmerman, “Innovative Technologies Enabling 10GBASE-T”, Network Systems Design Conference, October 2005.

G. Zimmerman, “Power Backoff”, IEEE P802.3an Task Force Contributions: Zimmerman_1_0205.pdf, Zimmerman_1_0305.pdf, Zimmerman_2_0305.pdf, February & March 2005.

G. Zimmerman, “Transmission Proposal for 10GBASE-T”, IEEE P802.3an Task Force Contribution Zimmerman_1_0304.pdf, March 2004.

G.A. Zimmerman & S. Rao “IEEE 802 10GBASE-T Tutorial: PHY”, IEEE 802.3 Plenary Tutorial, http://www.ieee802.org/3/10GBT/public/nov03/10GBASE-T_tutorial.pdf, November 2003.

G.A. Zimmerman, “Challenges for 10Gb/s on UTP Media”, Communications Design Conference, Sept 30, 2003.
G. Zimmerman and W. Jones, “10GBASE-T Challenges and Solutions”, IEEE 802.3 Plenary Tutorial, http://www.ieee802.org/3/tutorial/nov02/tutorial_1_1102.pdf, November 11, 2002.

G. A. Zimmerman, “Achievable rates vs. operating characteristics of local loop transmission: HDSL, HDSL2, ADSL and VDSL”, Signals, Systems & Computers, 1997. Conference Record of the Thirty-First Asilomar Conference on Signals, Systems and Computers, Volume 1, 2-5 Nov 1997 Page(s):573 - 577 vol.1

G.A. Zimmerman, “Normative Text for Spectral Compatibility Evaluations”, PairGain contribution, T1E1.4/97-180R1, June 30, 1997.

G.A. Zimmerman, “OPTIS HDSL2: Performance and Spectral Compatibility”, PairGain contribution, T1E1.4/97-237, June 30, 1997.

G.A. Zimmerman, “Approaches to CSA-Reach Single-Pair HDSL”, PairGain contribution, T1E1.4/96-063, April 1996.

M.J. Flanagan and G.A. Zimmerman, “Spur-Reduced Digital Sinusoid Synthesis”, IEEE Transactions on Communications, Vol. 43, No. 7, July 1995, pp. 2254-2262.

Ian Galton and George Zimmerman “Combined RF Phase Extraction and Digitization”, 1993 IEEE International Symposium on Circuits and Systems, Chicago, Illinois, pp. 1104-1107, May 1993.

G.A. Zimmerman and M.J Flanagan, “Spur-Reduced Numerically-Controlled Oscillator for Digital Receivers”, 26th Annual Asilomar Conference on Signals, Systems, and Computers, October 26-28, 1992.

G.A. Zimmerman, “Applications of Frequency Modulation Interference Cancellers to Multi-access Communications Systems,” Ph.D. Thesis, June 1990, California Institute of Technology.

G.A. Zimmerman and E.T. Olsen, “Analysis of I/O Efficient Order-Statistic-Based Noise Power Estimators”, IEEE International Conference on Acoustics, Speech and Signal Processing, March 1992.

G.A. Zimmerman, M.F. Garyantes, and M.J. Grimm, "A 640-MHz 32-Megachannel Real-Time Polyphase-FFT Spectrum Analyzer," 25th Annual Asilomar Conference on Signals, Systems, and Computers, November 1991.

G.A. Zimmerman and S. Gulkis, "Polyphase-FFT Spectrum Analysis for the SETI Sky Survey", Joint USA-USSR Conference on the Search for Extraterrestrial Life, August 1991, Santa Cruz, California.

J. Statman, G. Zimmerman, F. Pollara, and O. Collins, "A Long Constraint Length VLSI Viterbi Decoder for the DSN", The Telecommunications and Data Acquisition Progress Report 42-95, November 1988.

HONORS

Senior Member, IEEE
Member, IEEE Standards Association, IEEE Communications Society, IEEE Solid State Circuits Society

IEEE-SA Standards Medallion, "for significant contributions to IEEE 802.3 Ethernet standards from strategic, technical and organizational perspectives." (9/17)

Member-at-Large IEEE-SA Board of Governors (term: 12/2020 – 12/2022)

Voting member of IEEE 802.3 Ethernet Working Group (current), including leadership roles:
Chair, IEEE 802.3 Greater than 10 Mb/s Long-Reach Single Pair Ethernet Study Group
Chair, IEEE P802.3de Enhancements to the MAC Merge function and the Time Synchronization Service Interface (TSSI) to Include Point-to-Point 10 Mb/s Single Pair Ethernet Task Force
Chair, IEEE P802.3de Power over Data Lines of Single Pair Ethernet (Maintenance #17) Task Force
Chair, IEEE P802.3cg 10 Mb/s Single Pair Ethernet Task Force
Chair, IEEE 802.3 10 Mb/s Single Pair Ethernet Study Group
Chief Editor, IEEE Std. 802.3bz-2016 2.5G/5GBASE-T
Chief Editor, IEEE Std. 802.3bq-2016 25G/40GBASE-T
Participant, IEEE P802.3bp 1000BASE-T1, IEEE P802.3bt 4 Pair Power over Ethernet, and IEEE P802.3bu Single Pair Power over Data Lines Task Forces.

Member, IEEE 802 Standards Committee – 802 Executive Committee Treasurer (7/18-present)

IEEE Standards Association Certificates of Appreciation
IEEE Std. 802.3bz-2016, 2.5G/5GBASE-T, IEEE Std. 802.3bq-2016, 25G/40GBASE-T, IEEE Std. 802.3an-2006, 10GBASE-T and IEEE Std. 802.3az-2010, Energy Efficient Ethernet

Member, National Fire Protection Association
Member, NFPA70/NEC® Task Group on Power over Ethernet (2020 code cycle)
Chair, NFPA70/NEC® Task Group on Communications (2023 code cycle)
Member, NFPA70/NEC® Code Making Panel 3, Special Expert (since 2020 code cycle)

Member, Telecommunications Industry Association,
Participant and voting member, TIA TR42 (2011 – current)
Member US TAG ISO/IEC SC25/WG3 (2012-2016)

Best Paper Award, Design SuperCon97, January 1997

NASA Monetary Awards for patent applications
"Method and Apparatus for Spur-Reduced Digital Sinusoid Synthesis" (12/94) and "A Large Constraint Length, High Speed Viterbi Decoder…" (5/91)

NASA Monetary Awards for NASA Tech Briefs:
"I/O Efficient RFI-Robust Order Statistic-Based Noise Power Estimators" (11/94), "Real-Time, Polyphase-FFT, 640 MHz Spectrum Analyzer" (11/94), "Spur-Reduced Numerically-Controlled Oscillator", (8/93), and "Large-Constraint-Length, Fast Viterbi Decoder," (10/89).

NASA Group Achievement Awards for:

The High Resolution Microwave Survey Team (3/93), The Advanced Error-Correcting Code Research and Development Team (6/92), The Magellan Radar Group (6/92), and The Advanced Digital SAR Processor Development Team (4/88)

F.E. Terman Award for Scholastic Achievement in Engineering (Stanford University) (2/85)

Tau Beta Pi National Engineering Honor Society (12/84), Phi Beta Kappa National Honor Society (5/83)

STATUS: US citizen, Elapsed EBI (Inactive)